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ADVANCED TACTICAL CREW SYSTEM (ATACS) ISSUES AND OPTIONS:
IMPACTS ON AIRCREW SELECTION AND TRAINING

By

Ronald G. Hughes

OPERATIONS TRAINING DIVISION
Williams Air Force Base, Arizona 85224

October 1981

Interim Report

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The Advanced Tactical Crew System (ATACS) is the present name for an ongoing planning exercise being performed by a working group (comprised of the Air Force Wright Aeronautical Laboratories (AFWAL) and five other Air Force laboratories) in accordance with a formal charter and direction from the Air Force Systems Command (AFSC). The ATACS working group is charged with the development of a new AFSC technical initiative to develop and demonstrate the cockpit crew system technology for the *next generation* Air Force fighter class aircraft.

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The Air Force Human Resources Laboratory was asked to advise the ATACS Design Team on issues pertaining to aircrew training and selection as these areas might potentially be impacted by alternative designs for the next generation fighter aircraft. The ideas and recommendations contained in this paper are preliminary and do not necessarily represent the official position of the Laboratory. Neither should they be taken as being descriptive of the full range of potential training and selection issues that might be encountered. They are merely "best guesses" based on current training practices and projected trends.

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A

PREFACE

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The Opportunity for Practice in the Simulator-Intensive Training Environment of 1990-and-Beyond

The threat environment of the 1990s presents significant challenges not only to the airframe and cockpit designer, but especially to those who concurrently seek to anticipate the training environment of the future. Should current trends toward rising fuel and munition costs, airspace restrictions, etc. continue, the training environment of the 1990s will, by necessity, be extremely *simulation-intensive*. Current user acceptance of simulators to the contrary, allowance must be made for the aircrew to adequately practice (if not indeed to *overlearn*) the performances upon which combat effectiveness and survivability depend.

Technology options envisioned for the design of the next generation fighter aircraft are expected to have far reaching impacts upon the areas of training and aircrew selection. In many instances, these technologies promise to provide for functions with which the current generation aircrew has little or no operational experience and for which the training system developer has an equally small amount of data from which to infer the potential impacts of these new technologies upon training.

Reduced pilot workload is being sought as a means of achieving acceptable levels of system operability. The relationship of workload (especially mental workload) to training (particularly as "training" here implies the opportunity to practice) needs to be clearly pointed out. "Operability" needs to be understood as, in large part, a goal of training, and not solely as a characteristic of cockpit display and control designs. The most operable system in the most workload efficient cockpit will not insure sought-after levels of combat readiness and survivability if not frequently and intensively exercised by the aircrew. While operability and workload reduction are necessary human engineering design goals, they represent only starting points in the design of a training system for the next generation fighter.

Basic Assumptions in the Design of Next Generation Training Systems

When the opportunity for the practice of mission essential skills is seen as a central training system design requirement, the focus is on the following assumptions. These assumptions provide a certain degree of organization to the potential training issues identified in the remainder of this paper.

1. There is no substitute for practice. While technological sophistication and automation may reduce operator workload, they may do so only through an increased demand upon operator practice time requirements.

2. That which is not frequently practiced will be forgotten. Periodic training results in periodic readiness.

The Need for Alternatives to Aircraft-Based Training Systems

Currently, the aircraft itself represents the central "training device" for the acquisition, maintenance, and reacquisition of tactical aircrew skills. Operational deployments and exercises such as RED FLAG represent real attempts to expose aircrews to combat-like situations. Their benefit to current training programs is not questioned. They are, however, unable to provide for the full range of variables

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known to affect performance in an "electronic" *combat environment.* The critical point, however, is that such exercises are not only extremely expensive (and will become even more so in the 1990s-and-beyond time frame), but that their "fidelity" is severely affected by the constraints of a peacetime training environment.

There is also a long history from other established training programs that shows "readiness" declining to unacceptably low levels during intervals between such operational exercises. While such exercises possess a clear and obvious relationship to readiness, their low frequency of occurrence has serious impacts on day-to-day levels of overall force readiness. It is to be expected based on the principle contained in Assumption 2 above which states that "what is not frequently practiced will be forgotten." Clearly, the tactical training systems of the 1990s-and-beyond must provide for not only necessary aircrew practice of critical tactical skills but also the manner in which such devices are used to ensure sustained, high levels of individual and crew readiness.

In short, training must be seen as a direct and significant contributor to readiness. In the 1990s, weapon system effectiveness is more likely to be upward bounded by constraints on training rather than by the lack of technological sophistication. Readiness does not equate with weapon system sophistication, but rather with the ability of the trained aircrew to effectively operate that system. It is inevitable that readiness in the 1990-and-beyond time frame will greatly depend on current efforts to develop an effective simulation capability for tactical aircrew training.

But where are the simulators that will rise to meet the demands that new systems place on training? What efforts are being taken to ensure that fully operational simulators will be fielded concurrently with the aircraft systems that they are intended to support? The notion of simultaneously developing new equipment and its supporting training system is not new; the merits of doing so will not be argued here. Instead, the following comments point to critical training system issues associated with actually implementing such an approach for the next generation fighter.

II. ADVANCED CONCEPTS IN TACTICAL TRAINING SIMULATION SYSTEMS

Centralized, Decentralized, and Hybrid Training Systems

The most obvious issues which arise with respect to the creation of a large scale tactical training simulation system are those dealing with *what, how many,* and *where.* The latter two are logistics questions, driven in large part by the general requirements for initial and continuation training and for Air Force needs for achieving a desired flow of pilots through such a system. While some attempt will be made here to describe alternative training system configurations differing in the extent of their centralization (the *how many* and *where* problems), system description and specification are not the major intents of the discussion. Rather, the chief intent is to point out that *the logistical aspects of conducting training under such large scale training systems lead to certain impacts upon training and readiness that are predictable from the elementary assumptions about the impacts of practice upon readiness.*

The notion of a centralized tactical training simulation system referred to here is essentially that of one or more large scale "centers" each possessing the capabilities through use of modularized cockpits and common use of image generation and computer support capabilities to provide multiple aircrews the opportunity to practice interactively, and in real time, all critical elements of representative combat missions. The definition of a decentralized facility might range at one extreme from a capability equal to that of the centralized facility itself, but located instead down at wing level, to training systems of less fidelity and capability relying largely on the integrated use of part-task training devices. "Hybrid" systems representing some combination of the decentralized and centralized system concepts might also exist.

The centralized training center is certainly attractive because of its apparent cost benefits over the decentralized facility concept. To duplicate the capabilities of a center at numerous remote locations would quite likely be prohibitive both in terms of cost and supportability. However, while decentralization (at least at the most extreme case) appears prohibitive in terms of cost, the decentralized concept would serve to avoid potential bottlenecks in flow as well as providing increased system reliability associated with increased system availability. Also, from the standpoint of unit readiness, the decentralized concept affords the individual aircrew more frequent access to the means for rehearsing critical mission tasks. Frequent access to the device would also aid in avoiding the undesirable "peaks" in readiness associated with centralized, periodic training.

An alternative to the solely centralized concept or to a solely decentralized (unit level) concept to training system design might be a system which effectively combined the merits of both. For example, a single centralized facility might serve to handle the recurring training needs of those forces operating within the same large geograpohical area. Visits to the center might be thought of as being somewhat analogous to current deployments to RED FLAG. The operation might be characterized by an intensive, quick response software support capability, allowing the facility to quickly tailor training to current operational needs and requirements. The center as mentioned before would evolve around a modular design allowing it to meet the training needs of a variety of aircraft systems. Such a centralized center could also provide an important tactics development and evaluation function not possessed at unit level. The configuration of such a large scale simulator facility might consist of four "platforms." The rationale for four is that it would allow for variation in flight size in addition to providing for the practice of a variety of "n-on-n" mixes for air combat tactics training.

Clearly a centralized facility could not by itself meet the needs for the sustained readiness of numerous geographically dispersed units. Some capability must be located at the unit level to insure that gains in readiness acquired at the centralized training facility are not lost in the interim. Duplication of the centralized center function at numerous remote sites is out of the question. However, it may be cost effective to consider the increased use of part-task devices and trainers of lesser fidelity than those available at the centralized site. To the extent that the critical tasks in the next generation fighter are those associated with systems management, these tasks lend themselves to the application of part task training technologies quite well. The requirement to maintain pilot proficiency in basic aircraft control might be satisfied through the use of less expensive, trainer aircraft not having the avionic requirements of the full mission aircraft. One derivative concept which has not been mentioned is that under such a "hybrid" concept, remote units might have the capability for interacting (e.g., by some form of data link) with the central site. The feasibility of such an interactive data link has already been demonstrated. The hybrid concept then might be seen as offering some degree of centralized control over decentralized training.

Regardless of the particulars of the design chosen, the important point from the standpoint of the overall training system and its relationship to readiness is that remote sites would provide for the needed frequency of practice to insure that performance gains acquired through extensive training at a central site are maintained. The goal of the training system designer should clearly be that of insuring a high and sustained level of unit readiness at the lowest cost.

Unanswered Questions

There are obviously numerous unanswered questions associated with whatever concept is adopted. First, the best way to define the aircrew skills necessary for combat effectiveness and survivability is not fully understood. Current task analytic descriptions usually do not imply what the underlying skills are, and in failing to do so, they are of little or no help in specifying the design of potentially effective part-task devices such as those that might be effectively employed at the unit level under a hybrid concept. Even assuming that the tasks could be described in terms of the required aircrew *skills* and that part-task trainers were to become more the rule than the exception, the proper "mix" of such devices into the

overall training system would still remain an empirical question. Similarly, *the most effective mix* between training conducted at the remote unit training facility, that conducted at the central training site, and that conducted in the aircraft remains to be specified.

Efforts at providing a training environment that allows for adequate part-task and whole-task practice of critical mission skills should not be abandoned because of such unanswered questions. The clear point to be made is that there is a desperate need to rapidly move in the direction of providing some *such capability. The opportunity* to acquire and to maintain critical mission skills using the actual aircraft will simply not be a viable option. Also, while the costs of such training systems will not be insignificant, *the analyst must consider the cost consequences associated* with low or fluctuating readiness levels.

Where might one begin in the process of *shaping* such a tactical training simulation capability in the near future? From where will the experience come to actually conduct tactical training in what will be a novel simulator environment? One possible answer is described below.

A "Pilot Factors" Approach to System Design and Training System Development

In the early 1970s, the Air Force created a facility, the purpose of which was to provide a "window to the world" for those involved in the development and evaluation of *control, display, and guidance* systems. Testing was conducted from the "pilot's point of view" (as opposed to engineering testing). As instrument display requirements were identified and developed, the Air Force Instrument Flight Center (AFIFC) had the capability of developing corresponding procedural and training requirements, and of validating the end product. A similar need currently exists with respect to the design and evaluation of *concepts for the next* generation fighter, many of which will be control, display, and guidance intensive. The AFIFC no longer exits. Even if it did, there is a clear requirement that the evaluation of technologies associated with *the design of the next generation fighter* be evaluated under the pressures and constraints of those variables operating in the high threat mission environment. Flight test methodology of the traditional type is becoming unaffordable as well as unrealistic. A *highly developed tactical simulation* capability appears to be essential to a 1980-1995 IFC-like function.

It has been recommended that the Operations Training Division of the Air Force Human Resources Laboratory (AFHRL) provide such a function, and that maximum use be made of emerging simulation technologies to do so. What benefits might such an AFHRL-provided function provide?

1. The present technical and professional staff of AFHRL/OT (formerly the Flying Training Division of AFHRL) has the expertise to conduct the type of "pilot factors" research, test, and evaluation *being sought* and, equally important, to communicate the findings of this type of research to the engineering community involved in design and redesign.

2. The primary focus of the existing research program at OT has been, and continues to be, on the area of *training and training effectiveness*. The same orientation that permits OT to conduct effective pilot factors research and evaluation of system "flyability" also permits it to treat the impact of such evaluations on training system development. AFHRL/OT comes as close to being able to provide an IFC function as any organization within the Air Force.

3. The mix of engineering and behavioral research expertise at OT allows it to investigate potential part-task training applications and to generate specifications for their eventual inclusion into *future* tactical training simulation systems such as those just discussed.

4. By providing the simulation capabilities to support the desired pilot factors type of evaluation, direction is given to the development of specific technologies for the eventual development of advanced tactical simulation capabilities to be used for operational training.

c. This in-house effort, by being conducted concurrently with the design phase of the actual aircraft system, represents a cost-effective alternative to the traditional post-product design and development of a supporting simulator training system capability. Essentially all of the necessary training system R&D would be conducted in-house by the Air Force. By being conducted within the context of an IFC-type model, not only would the work lead to the hardware design for the training system, but the training methodologies as well.

III. CREW STRUCTURE AND COCKPIT DESIGN

Impacts on Training and Selection

The previous sections have addressed the need for providing the aircrew of the 1990s with the necessary opportunity for practicing critical mission tasks in what is projected to be a simulation-intensive training environment. Centralized, decentralized, and hybrid configurations of large scale tactical training system "networks" were mentioned. Tradeoffs, both in terms of implied costs and in terms of unit readiness stability, were also discussed. How provision of an IFC-like function might be satisfied by AFHRL/OT was described in terms of its role in providing important "pilot factors" information for designers as well as its role in shaping the actual training system design and methodologies of the future.

The present section changes the focus from that of the capability of current and future aircrew training systems to provide sufficient opportunity for practicing critical mission skills to the potential training and selection implications of one- and two-man cockpit designs.

The starting point for the traditional consideration of one- versus two-man cockpit designs for the 1990s fighter appears to center on the concern over the ability of the single pilot to handle both the flight control and systems management functions simultaneously. Since the crewmember who physically "flies" the aircraft is traditionally thought of as the primary crewmember, the "traditional" solution is to attempt to unload all or part of the systems management (backseat) function on a second crewmember. A close look at the relative contribution of flight control and systems management functions to overall weapons systems effectiveness shows that the backseat function is highly critical. Essentially the backseater is the "flight leader." If one looks, too, at which crewmember responsibilities lend themselves to potential automation and which will, at least in the 1980-1995 timeframe, still require the human operator, it is the backseater function which will probably remain most in need of the human operator.

Despite the fact that the backseater is the apparent overall systems manager and the true "flight leader," those who concern themselves with personnel, manpower, selection, and the like continue to focus on the pilot function. It is suggested that when considering impacts upon selection, the emphasis be placed upon the backseater as the aircraft commander and that secondary emphasis be placed upon the pilot (i.e., driver). The implications for designers is that it now becomes a case where alternative designs look for the most effective way in which to "unload" flight control functions from the backseat to the pilot in the front seat. Such a concept is not new. It is already the way in which the Royal Air Force (RAF) treats crew station management for the Tornado aircraft. Too, it is rarely the case in any weapon system that the operator in charge of its tactical employment is also the one who physically "drives" it around.

What might the impacts of such a rethinking of major crewmember roles and responsibilities have upon training and selection? Placing primary emphasis on the responsibilities of the weapons systems manager would serve to significantly relax entry level pilot (front seat) requirements. General educational level and cognitive/intellectual abilities would become less of a driving factor in pilot selection. Large fill rates out of UPT would become of less concern if the major tactical aircraft functions were performed by an experienced crewmember in the back seat. In relaxing the entry level requirements for pilots, per se, a significantly enlarged pool of pilot candidates emerges. With the overall requirements relaxed in this way, there is no inherent reason why pilots need to be college graduates nor that there be any expectation that

the pilot of today need be groomed for anything other than the role of pilot (as opposed to the current grooming for higher level command and staff positions). In short, some rethinking of the implications for different crew structures based on changing emphases of who "flies" the aircraft and who "controls" the aircraft leads to the following conclusions.

1. The "backseater" is extremely critical in terms of his overall impact on tactical weapon system deployment, overall mission effectiveness, and survivability. The cognitive and information processing requirements of potential importance for selection are those associated with the person performing the systems management functions, not with the person performing the flight control functions.

2. Overall weapon system training costs might be reduced by being able to train the pilot of the system in an aircraft not having the fully operational avionics of the actual aircraft. To the extent that cockpit standardization of the pilot portion of the cockpit could be achieved, it would become possible even to train a "universal pilot" for advanced tactical aircraft (or at least for those having a common mission). Too, a change in focus to that of the "career" pilot might serve indirectly to reduce operating costs currently associated with mid-career attrition of pilots.

Alternatives of the Manned Weapon System Concept

The crew station design issue and its potential impacts upon aircrew selection and training derives its importance from a continued adherence to the concept of the manned weapon system. Considerations of alternative designs would appear to be critical given our present understanding of the battlefield environment of the 1990s and the projected risks associated with still rather conventional weapon systems and tactics in such an environment. Cost-per-kill and cost-per-kill *rate*, are, or will become, driving factors. We simply cannot afford to lose a significant number of 30-million-dollar-plus weapon systems and their crews in order to achieve an overall number and rate of enemy kills that do not serve to affect significantly the course of the battle. To try to "design-in" high levels of survivability will be costly. The extent to which training can reduce these costs and significantly increase survivability remains an open question. A strictly physical analysis of the battlefield, however, and its impact on aircrew training requirements would suggest that training, even at its best, may not significantly reduce the expected high levels of attrition.

It is imperative that new technologies in the armaments and munitions areas be considered, especially those that would permit the aircrew to launch "smart" weapons, each having the potential for multiple kills, and to do so from standoff ranges that would minimize the risk to the aircrew. Aircrew attrition and attrition due to the loss of the weapon system platform itself could potentially be reduced greatly. . . both, however, at the added expense of weapon system guidance. The basic question is, in short, whether tactical air warfare (at least in the air-to-surface area) is more cost effective (from a cost-per-kill or a cost-per-kill *rate* standpoint) when using costly, sophisticated aircraft and highly trained crews to deliver dumb bombs or when using less costly aircraft and less highly trained aircrews to deliver smart weapons?

IV. SUMMARY

The training environment of the 1990s-and-beyond will, by necessity, be *simulation-intensive*. A failure to plan for training and cost-effective alternatives to aircraft-based training concepts will result in the inability of aircrews to adequately practice mission essential skills. In the consideration of tactical training system alternatives, careful thought must be given to the subtle relationships between the scheduling of aircrew practice and its impact upon sustained unit readiness. Such considerations should be inherent in decisions based upon the cost tradeoffs of centralized and decentralized training systems. The full impact of training upon mission readiness and survivability must not be underestimated. While

operability and reduced pilot workload remain essential human engineering design goals, they must be viewed as necessary, but not sufficient, conditions for achieving overall goals for weapon system effectiveness. There is every reason for reversing the current trend toward first producing the weapon system and then its training system. Efforts must be initiated to provide for the concurrent fielding of operational equipment and its supporting training system and devices. A means for doing this is seen as an important byproduct of the re-establishment of a "pilot factors" program, similar to the function performed by the former AFIFC facility. A proposal that AFHRL/OT provide such a function would do three things: (a) provide the design community with essential feedback with respect to "flyability" of new design concepts, (b) provide the training community with the early exposure to the system necessary to formulate training system methodologies and structures, and (c) provide an important simulation test-bed for the development and validation of feasible engineering designs and approaches for next generation trainers. Finally, the implications for aircrew selection and training which follow from an elementary rethinking of the one- versus two-man cockpit concept were discussed. It was pointed out how a shift in emphasis from the flight control function to the systems management function might result in potential efficiencies in terms of enlarging the potential pool of pilot candidates, pilot retention, and for the potential of being able to train a "universally assignable fighter pilot." It was also pointed out that one should remain open to alternatives to the manned weapon system concept. The sensitivity of cost-per-kill and cost-per-kill *rate* should be fully explored as a function of "smart plane/dumb weapon" versus "dumb plane/smart weapon" concepts.